A GRAPHIC ANALYSIS OF TOUCH TECHNIQUE SAFETY.

By

Mark M. Uslan and Paul Manning


EX LIBRIS

C. 1

A GRAPHIC ANALYSIS OF TOUCH TECHNIQUE SAFETY

Mark M. Uslan*
Paul Manning**

Within the field of orientation and mobility there exists the view that the inherent limitations of the cane and the inherent deficiencies of the scanning method of using the cane can only be minimized by the resourceful application of the blind user's ingenuity (Suterko, 1967). Thus, overcoming deficiencies of the "touch technique" is an art which only the resourceful blind person can master. Those who hold to this view would say that since there are degrees of resourcefulness, there are degrees of mastery of the touch technique. Yet one must not lose track of the role of the peripatologist. It is his job to create impetus in learning touch technique; and it is also his job to reduce the limitations of the cane as a tool, and the deficiencies of the scanning method. The user is the dependent variable, but neither the cane nor the method are unvarying constants.

The touch technique is a systematic procedure for using the long cane in safe and efficient travel for blind persons. Its proper use involves the mastery of some basic technique. The dominant hand must be in the center of the body with the index finger pointing straight down along the cane. The wrist is pivoted so that the tip of the cane describes an arc in front of the user, touching the ground lightly on each side. As it describes the arc, the tip should just clear the ground so that low protruding objects may be detected. The arc must be equidistant from the center on both sides, to allow for proper coverage of the entire body. The cane tip is moved in a rhythmic motion across the body in step with the feet so that when the left foot steps forward, the cane makes its arc to the right, and when the right foot steps forward, the cane makes its arc to the left.

When this technique is mastered, many travelers still continue to collide with objects. Few mobility instructors will dispute that even when executed properly, basic touch technique is not 100 percent safe. Yet most will say that the margin of safety in basic cane technique is still acceptable. But the question of safety cannot be resolved until the touch technique is rigorously analyzed. Should not the instructor strive for 100 percent safety for as large a proportion of the blind population as possible?

The vicious cycle that keeps the poor mobility student from achieving his optimum potential is caused too often by the fear of traveling unsafely. To halt the cycle the instructor strives to instill confidence. The most reassuring way of doing so is to ensure safety-enhancing technique and combine it with adequate execution, good judgment, and short reaction latencies. The instructor must know what safe technique consists of; and he must be able to teach the technique without causing frustration and resentment. Fast reaction and

*Indiana University.

**Rensselaer Polytechnic Institute.

the exercise of good judgment are most often learned with practice.

It is our purpose to scrutinize aspects of safety in touch technique and execution of the touch technique by defining crucial variables and proposing modifications in existing technique. Once an optimally safe technique is established, it is possible to improve training in its practice by using monitoring devices to give the traveler and his instructor appropriate information on deviations from an individual's optimum cane technique.

ANALYSIS OF EXISTING TECHNIQUE

A safety analysis of touch technique is composed of two parts: analyzing existing technique, and analyzing the execution of that technique. A complete analysis of existing technique entails the determination of relevant variables present, analyzing the variables, and suggesting corrective procedures.

Our analysis was aided by charting the path of the cane projected on the ground. Prior work has shown that the velocity of normal walking patterns closely approximates a constant (Murray, Drought, Bernard, and Kory, 1964). Hence, no effort was made to monitor an irregular walking speed. An irregular cane velocity was also ignored because an average of the path arcs created by an irregular cane velocity caused minimal distortion.

The crucial variables in touch technique, assuming perfect execution, are cane length, the height of cane hand off the ground while the cane is in operation, and step length or stride. The length of the projection of the cane on the ground (R) is controlled by the length of the cane (CL) and the height of the hand off the ground (H). Therefore $R^2 = (CL)^2 - H^2$. Stride governs the size of unprotected areas of vulnerability if cane length and height of hand remain constant. Areas of no protection increase in size as stride increases. In this analysis the distance from the cane hand to the body is not a variable affecting the size of unprotected areas because the graphs are designed to treat the cane hand as a plane the same width as the body and parallel to it. If this plane is fully protected then the body behind this plane is protected. Lastly, the speed of the traveler is irrelevant as long as optimal touch technique is maintained at high speeds.

MODIFICATION OF EXISTING TECHNIQUE

Experimenting with different graph methods revealed the fact that touch technique can be modified to produce much better protection. The conventional technique of pivoting just the wrist, with the arm stationary, was found to be much less safe than swinging the forearm with minimal wrist action and pivoting from the elbow. When mapping conventional touch technique, we found that there are vast unprotected areas, equal on each side of the traveler, which cannot be eliminated. No mapping of results from canes of differing specifications resulted in significant reduction in areas of vulnerability. The advantages of the forearm swing are illustrated when graphs of identical specifications of step-size, height-of-hand-off-ground, and cane-length used with the conventional technique and a modified technique (using forearm swing) are compared (Figs. 1 and 2).* The drawback of a stationary forearm can be clearly illustrated: the unprotected area juts dangerously into the path of travel. Such comparisons were constructed for a wide range of different specifications of step-size, height-of-hand-off-ground, and cane-length. Our results showed consistently that swinging the arm significantly reduces areas of no protection. It should be remembered that these graphs assume perfect execution and hence, show the best possible coverage for the given cane specification.

A logical outgrowth of touch technique analysis is the compilation of a set of optimum values of the

---

*In all graphs:
. = cane hand position, and
/ or \ = cane tip position.

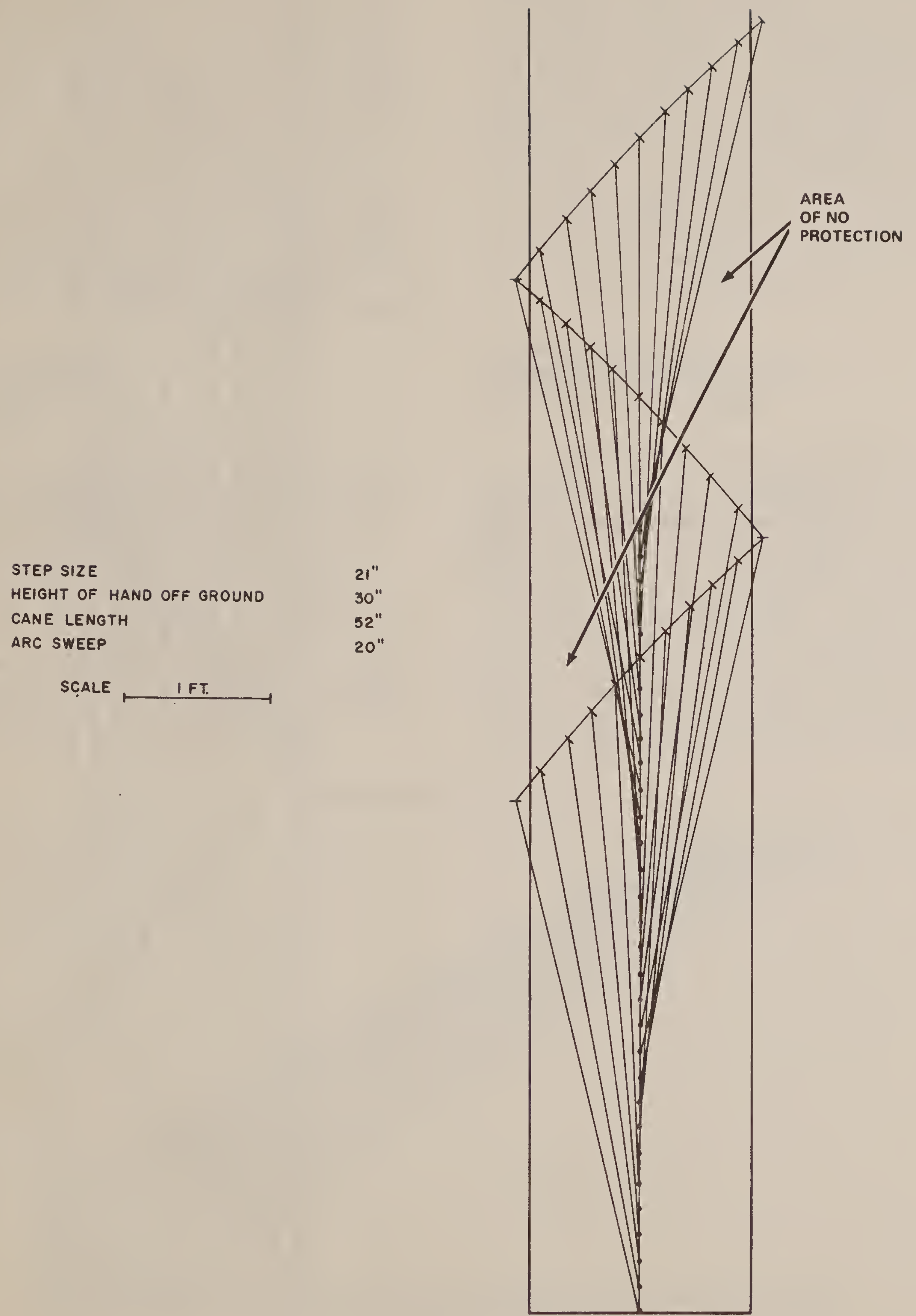


Figure 1. The Conventional Touch Technique (Wrist Pivot)

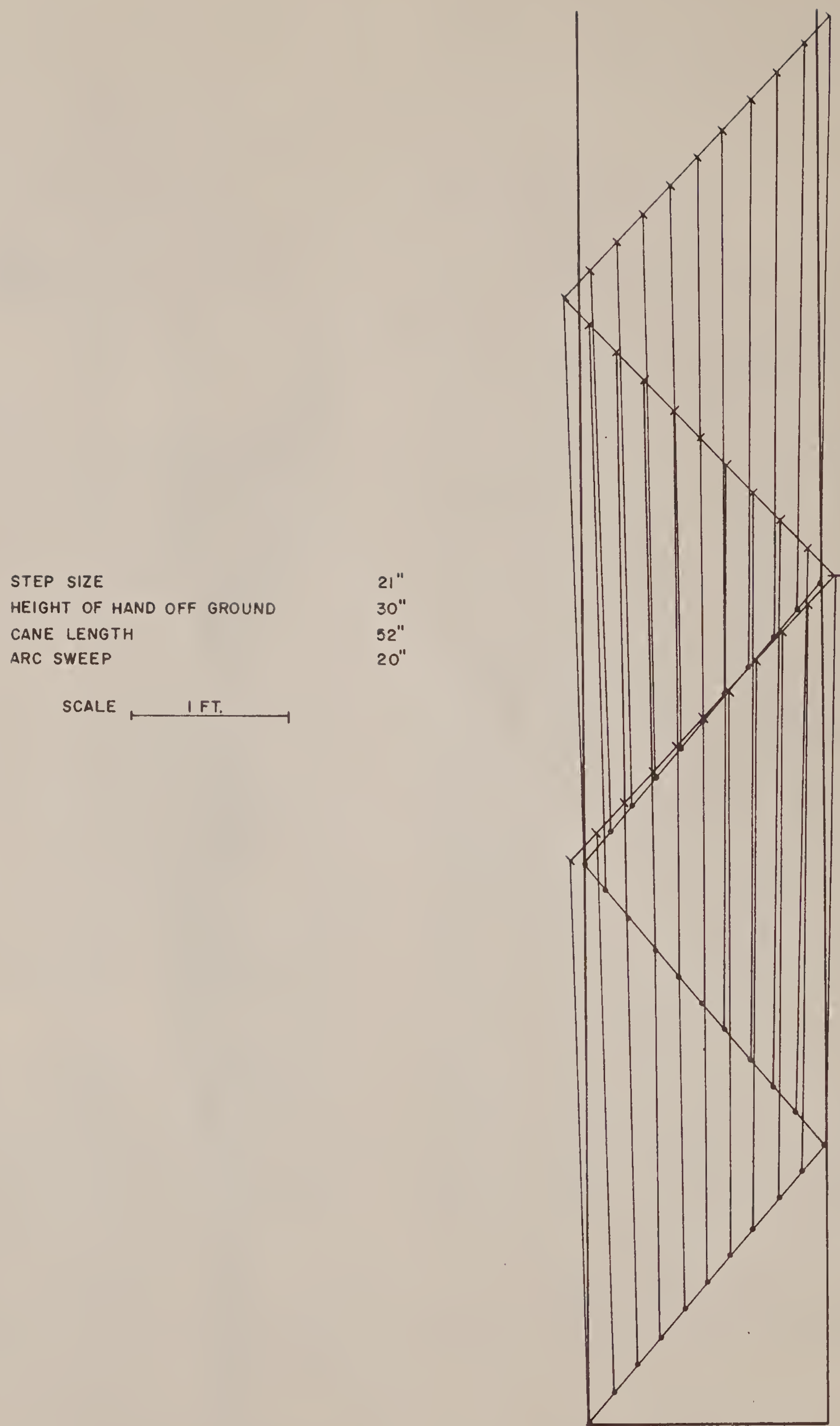


Figure 2. The Modified Technique (Forearm Swing)

variables for all individuals. A chart of such values was derived from numerous maps of several cane specifications; and an index was made from it (Fig. 3). The chart enhances the attainment of maximum safety and assumes perfect execution of cane technique. Thus, for an individual with a given height of cane hand from the ground and a given stride we are able to determine the proper cane length for safest travel. For example, a traveler with a 21-inch stride and a 30-inch height of hand from ground would travel most safely using a cane no shorter than 52 inches. Any body width is covered by the index as long as the cane tip hits the ground at least one inch outside shoulder width.

TOUCH TECHNIQUE EXECUTION AND MONITORING

The problem of poor execution of the touch technique begins when basic techniques are being learned. The importance placed on basic cane technique is underscored by the large blocks of time that are set aside by instructors for teaching it. When a student has difficulty learning basic techniques, the instruction time involved increases very rapidly. Under the pressures of reducing instruction time, some bad habits are often established, as basic techniques are learned. Actually the instructor can expect only a reasonable approximation of perfect touch technique execution. Moreover, perfection in learning basic methods is also compromised by the instructor's internal standard of what is acceptable, based on his perception of the student's ability. Typically the learning of basic technique is considered complete when a given time unit spent on instruction no longer results in improvement comparable to earlier stages. In other words, the law of diminishing returns affects the instructor's evaluation of an acceptable standard of basic technique execution.

SUGGESTIONS FOR IMPROVING EXECUTION OF BASIC TECHNIQUE

Perhaps the optimum aid to swift and accurate learning of basic technique is to monitor mobility behavior and attempt to shape it using simultaneous feedback. A practical and self-contained electronic monitor in synchrony of step and cane tip arcuate motion is now possible. Arc width monitoring and stride monitoring are more complex, but are certainly possible. Monitoring might allow large variances at the outset of training, and gradually narrow the range of

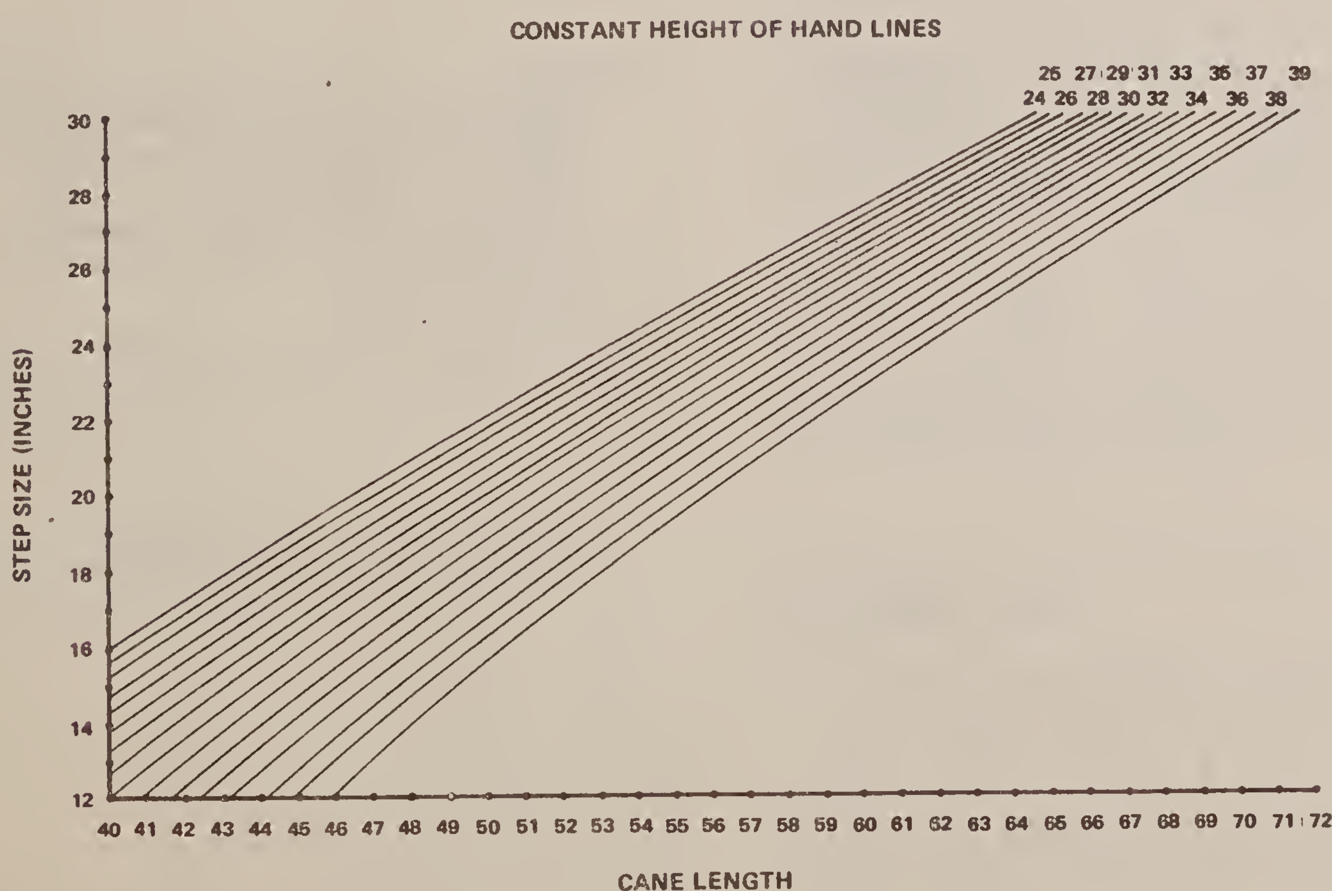


Figure 3. Safety Index

acceptable performance as instruction proceeds. The use of variable control monitoring devices to shape behavior implies a minimum of instructor interference. The level of student frustration directed toward the instructor would be reduced since perception of proper execution is left to the monitor-user system. Basic technique would be learned in a context of safety-oriented behavior, not on what seems acceptable according to the instructor's perception of individual ability. Spot checking basic cane technique safety during the latter stages of mobility training could then concentrate on extinguishing poor habits acquired after the learning of basic technique. In sum, future work might be directed with profit toward the feasibility of using electronic monitors to enhance the learning of optimally "safe" cane technique.

REFERENCES

Murray, M. Pat, Drought, A. Bernard, & Kory, Ross C. Walking patterns of normal men. *Journal of Bone and Joint Surgery*, 1964, 46A, 335-60.

Suterko, S. Long cane training: Its advantages and problems. *Proceedings: Conference for mobility trainers and technologists.* Cambridge, Mass.: MIT, Sensory Aids Evaluation and Development Center, 1967, 13-18.

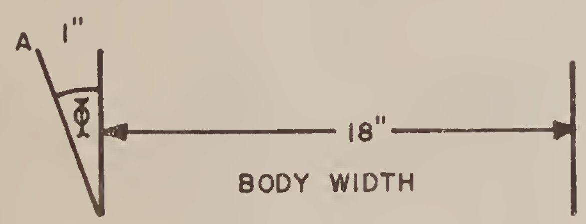
A Graphic Analysis of Touch Technique Safety

The following is a discussion of the method used to chart the path of the cane. All numbers are in reference to Fig. 5.

Let R be the length of the cane projected on the ground. Let (CL) be the cane length and let H be the height of the cane hand off the ground. Therefore, $R^2 = (CL)^2 - H^2$ which is $R^2 = 45^2 - 30^2 = 1125$ so $R = 33.5"$.

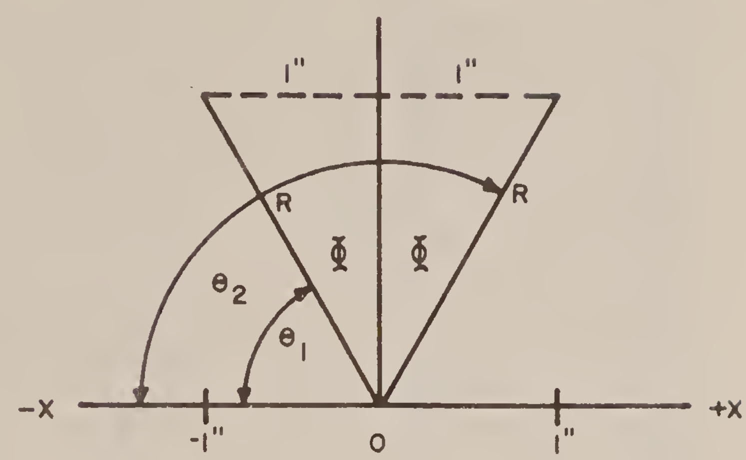
In the modified technique, the motion of the cane is composed of two parts. One type of motion is caused by wrist action (contributing a small arc) and the other type is caused by forearm motion. The motion from the wrist action is discussed below.

In Fig. 5, the body width is assumed to be 18" so there is a 20"-arc swing (one inch of extra coverage on each side). Let ϕ be the angle that the wrist turns in its motion to give a 20"-arc swing for a shoulder width of 18".



Note that Point A is the position of the cane tip when the cane is at the extreme left.

Just considering wrist motion, i.e. body width 0", the following diagram can be made.



$\sin \phi = 1"/R = 1"/33.5 = 0.0316$ so

$\phi = 1.8$

θ values range from θ_1 to θ_2 as the cane moves from the far left to the far right where $\theta_1 = 90° - 1.8° = 88.2°$ and $\theta_2 = 90° + 1.8° = 91.8°$. The graph is made in ten intervals for one traverse across the body. They are labeled 1 to 11 in the data tables. The total range of θ is $91.8° - 88.2° = 3.6°$ so the change in θ for each interval is $3.6/10 = 0.36$. Therefore, for position 1, $\theta = 88.2°$; for position 2, $\theta = 88.2° + 0.36° = 88.56°$; for position 3, $\theta = 88.2° + 0.36° + 0.36° = 88.92°$; etc. Position 1 occurs when the cane is at the far left and position 11 occurs when it is at the far right. Wrist motion is taken into account in the data table in columns x' and y'. The forearm motion is taken into account in the data table in columns P and H.

<u>Columns on the Data Table for Each Graph</u>

x' is the component of the wrist arc in the x direction (arm stationary). $x' = R \cos \theta$.

y' is the component of the wrist arc in the y direction (arm stationary). $y' = R \sin \theta$.

P is the component of the position of the hand in the y direction. Assuming constant velocity, it is simply the step size (1/2 the stride; heel to heel) divided by the number of intervals, i.e., 10. P for position 1 is 0; P for position 2 is 0 + 21/10 = 2.1; P for position 3 is 0 + 2.1 + 2.1 = 4.2; etc. P for position 11 is 21.

H is the component of the position of the hand in the x direction, due to the forearm motion. The forearm swings 18" (the assumed body width) in the x direction through positions 1 to 11. The length in the forearm travels is an interval (18/10 = 1.8). H at position 1 is -9" since position 1 is where the cane and the hand are at the extreme left. H at position 2 is -9 + 1.8 = -7.2; H at position 3 is -9 + 1.8 + 1.8 = -5.4; etc. At position 11, H is 9. (H, P) gives the location of the hand for points on the graph.

The columns x and y are the x and y coordinates of the cane position. $x = (H + x')$ is the sum of x components of the two types of motion that make up the forearm swing mentioned previously. $y = (P + y')$ is the sum of the y components. The (x, y) coordinates of hand position are simply (H, P). The points (H, P) on the graphs are represented by dots while the $[(H + x'), (P + y')]$ points are represented by slashes. The connected points represent a projection of the cane position on the ground for each of the points. Positions 1 to 11 on the data table comprise only one step. The other steps are symmetrical.

Four walking steps are necessary for a complete graphic representation. The first and the last steps are not indicative of cane travel because they are the starting and stopping steps.

SAFETY INDEX

Figure 5 does not have complete cane coverage and cannot be used in the safety index. It serves as a starting point to "guess" the proper cane length for complete protection. In order to arrive at the proper cane length, one must get point 1' to have a y coordinate of 42 (R = 42). Using $R^2 = (CL)^2 - H^2$, the cane length is 51.6". Total protection is attained in Fig. 2 with a cane length of 52".

The step size in Fig. 2 is 21". The R value needed for complete protection is twice the step size (42"). Figures 6 and 8 show the formula working for a 33" step and Fig. 7 shows it working for a 24" step. The preceding three graphs have R values slightly greater than twice the step size. The cane becomes an integral value length. The extra tenths of an inch on the R values show up on the graphs as overprotection.

DATA FOR THE SAFETY INDEX

Cane length deduced from patterns such as the case of the constant height of hand line of 30". Figures 2 and 6 were both deduced using an R of two times the step size and then finding the length of the cane to the nearest inch. Figures 2 and 6 had two extreme sizes of 21" and 33" respectively. The cane lengths of the step sizes in between these two step sizes can be calculated in the same way.

* Since relationships are linear (20" arc sweep), results of 30" and 39" constant height of hand lines can be carried through the remainder of the table.

	Height of Hand (inches)	Step Size (inches)	Cane Length (inches)
*	24	21	48.4
*	24	24	53.6
*	24	27	59.1
*	24	30	64.6
*	24	33	70.2
*	25	21	48.9
*	25	24	54.0
*	25	27	59.5
*	25	30	65.0
*	25	33	70.6
*	26	21	49.4
*	26	24	54.5
*	26	27	60.0
*	26	30	65.4
*	26	33	71.0
*	27	21	50.0
*	27	24	55.1
*	27	27	60.4
*	27	30	65.8
*	27	33	71.4
*	28	21	50.5

	Height of Hand (inches)	Step Size (inches)	Cane Length (inches)		Height of Hand (inches)	Step Size (inches)	Cane Length (inches)
*	28	24	55.6	*	35	27	64.4
*	28	27	60.9	*	35	30	69.4
*	28	30	66.2	*	35	33	74.7
*	28	33	71.8	*	36	21	55.3
*	29	21	51.0	*	36	24	60.0
*	29	24	56.1	*	36	27	65.0
*	29	27	61.3	*	36	30	70.0
*	29	30	66.6	*	36	33	75.2
*	29	33	72.2	*	37	21	56.0
	30	21	51.6	*	37	24	60.6
#	30	24	56.6	*	37	27	65.5
#	30	27	61.8	*	37	30	70.5
#	30	30	67.0	*	37	33	75.6
	30	33	72.5	*	38	21	56.6
*	31	21	52.2	*	38	24	61.2
*	31	24	57.0	*	38	27	66.0
*	31	27	62.3	*	38	30	71.0
*	31	30	67.5	*	38	33	76.2
*	31	33	72.9	#	39	21	57.3
*	32	21	52.8	#	39	24	61.8
*	32	24	57.6	#	39	27	66.6
*	32	27	62.8	#	39	30	71.6
*	32	30	68.0	#	39	33	76.6
*	32	33	73.4	#	24	16	40.0
*	33	21	53.4	#	26	16	41.0
*	33	24	58.2	#	28	16	42.4
*	33	27	63.3	#	30	16	43.9
*	33	30	68.4	#	30	14	41.0
*	33	33	73.8	#	32	16	45.3
*	34	21	54.0	#	32	12	40.0
*	34	24	58.8	#	34	16	46.8
*	34	27	63.8	#	34	12	41.7
*	34	30	69.0	#	36	16	48.1
*	34	33	74.2	#	36	12	43.2
*	35	21	54.6	#	38	16	49.7
*	35	24	59.4	#	38	12	44.9

Data Figure 1

Step Size 21"
Cane Length 52"
Height of Hand 30"
Arc Width 20"

Position	θ	y'	x'	P	H	y	x
1	76.40	41.3	-10.0	0	0	41.3	-10
2	79.12	41.7	-8.0	2.1	0	43.8	-8
3	81.84	42.1	-6.0	4.2	0	46.3	-6
4	84.56	42.3	-4.0	6.3	0	48.6	-4
5	87.28	42.4	-2.0	8.4	0	50.8	-2
6	90.00	42.5	0	10.5	0	53.0	0
7	92.72	42.4	2.0	12.6	0	55.0	2
8	95.44	42.3	4.0	14.7	0	57.0	4
9	98.16	42.1	6.0	16.8	0	58.9	6
10	100.88	41.7	8.0	18.9	0	60.6	8
11	103.60	41.3	10.0	21.0	0	62.3	10

Data Figure 2

Step Size	21"
Cane Length	52"
Height of Hand	30"
Arc Width	20"

For the values of θ, x', sin θ, refer to Fig. 5.

Position	y'	H	P	x	y
1	42.4	-9.0	0	-10	42.4
2	42.4	-7.2	2.1	-8	44.5
3	42.4	-5.4	4.2	-6	46.6
4	42.4	-3.6	6.3	-4	48.7
5	42.4	-1.8	8.4	-2	50.8
6	42.4	0	10.5	0	52.9
7	42.4	1.8	12.6	2	55.0
8	42.4	3.6	14.7	4	57.1
9	42.4	5.4	16.8	6	59.2
10	42.4	7.2	18.9	8	61.3
11	42.4	9.0	21.0	10	63.4

Data Figure 4

Step Size	24"
Cane Length	54"
Height of Hand	39"
Arc Width	25"

Position	θ	cos θ	sin θ	x'	y'	P	H	x	y
1	85	.087	.996	-3.22	36.85	0	-9.0	-12.22	36.85
2	86	.070	.998	-2.6	36.95	2.4	-7.2	-9.8	39.35
3	87	.052	.999	-1.9	≃37.0	4.8	-5.4	-7.3	41.8
4	88	.035	.999	-1.3	≃37.0	7.2	-3.6	-4.9	44.2
5	89	.017	1.	-0.6	≃37.0	9.6	-1.8	-2.4	46.6
6	90	0	1.	0	37.0	12.0	0	0	49.0
7	91	.017	1.	+0.6	≃37.0	14.4	1.8	2.4	51.4
8	92	.035	.999	+1.3	≃37.0	16.8	3.6	4.9	53.8
9	93	.052	.999	+1.9	≃37.0	19.2	5.4	7.3	56.2
10	94	.070	.998	+2.6	36.95	21.6	7.2	9.8	58.55
11	95	.087	.996	+3.22	36.85	24.0	9.0	12.22	60.85

Data Figure 5

Step Size	21"
Cane Length	45"
Height of Hand	30"
Arc Width	20"

Position	θ	cos θ	sin θ	x'	y'	P	H	x	y
1	88.20	-.031	≈1	-1.0	33.5	0	-9.0	-10.0	33.5
2	88.56	-.025	≈1	-0.8	33.5	2.1	-7.2	-8.0	35.6
3	88.92	-.019	≈1	-0.6	33.5	4.2	-5.4	-6.0	37.7
4	89.28	-.012	≈1	-0.4	33.5	6.3	-3.6	-4.0	39.8
5	89.64	-.006	≈1	-0.2	33.5	8.4	-1.8	-2.0	41.9
6	90.00	.000	1	0	33.5	10.5	0	0	44.0
7	90.36	.006	≈1	0.2	33.5	12.6	1.8	2.0	46.1
8	90.72	.012	≈1	0.4	33.5	14.7	3.6	4.0	48.2
9	91.08	.019	≈1	0.6	33.5	16.8	5.4	6.0	50.3
10	91.44	.025	≈1	0.8	33.5	18.9	7.2	8.0	52.4
11	91.80	.031	≈1	1.0	33.5	21.0	9.0	10.0	54.5

Data Figure 6

Step Size	33"
Cane Length	73"
Height of Hand	30"
Arc Width	20"

Position	θ	cos θ	sin θ	x'	y'	H	P	x	y
1	89.10	-.0157	1	-1.0	66.5	-9.0	0	-10	66.5
2	89.28	-.0126	1	-0.8	66.5	-7.2	3.3	-8	69.8
3	89.46	-.0095	1	-0.6	66.5	-5.4	6.6	-6	73.1
4	89.64	-.0062	1	-0.4	66.5	-3.6	9.9	-4	76.4
5	89.82	-.0033	1	-0.2	66.5	-1.8	13.2	-2	79.7
6	90.00	0	1	0	66.5	0	16.5	0	83.0
7	90.18	.0033	1	0.2	66.5	1.8	19.8	2	86.3
8	90.36	.0062	1	0.4	66.5	3.6	23.1	4	89.6
9	90.54	.0095	1	0.6	66.5	5.4	26.4	6	92.9
10	90.72	.0126	1	0.8	66.5	7.2	29.7	8	96.2
11	90.90	.0157	1	1.0	66.5	9.0	33.0	10	99.5

Data Figure 7

Step Size	33"
Cane Length	77"
Height of Hand	39"
Arc Width	20"

For the values of x', H, and x, refer to Fig. 6.

Position	y'	P	y
1	66.4	0	66.4
2	66.4	3.3	69.7
3	66.4	6.6	73.0
4	66.4	9.9	76.3
5	66.4	13.2	79.6
6	66.4	16.5	82.9
7	66.4	19.8	86.2
8	66.4	23.1	89.5
9	66.4	26.4	92.8
10	66.4	29.7	96.1
11	66.4	33.0	99.4

Data Figure 8

Step Size	24"
Cane Length	62"
Height of Hand	39"
Arc Width	20"

For values of H, x', and x, refer to Fig. 6.

Position	y'	P	y
1	48.2	0	48.2
2	48.2	2.4	50.6
3	48.2	4.8	53.0
4	48.2	7.2	55.4
5	48.2	9.6	57.8
6	48.2	12.0	60.2
7	48.2	14.4	62.6
8	48.2	16.8	65.0
9	48.2	19.2	67.4
10	48.2	21.6	69.8
11	48.2	24.0	72.2

STEP SIZE	24"
HEIGHT OF HAND	39"
ARC WIDTH	25"
CANE LENGTH	54"

STEP SIZE	21"
HEIGHT OF HAND	30"
ARC WIDTH	20"
CANE LENGTH	45"

SCALE 1 FT.

TYPICAL AREAS OF NO PROTECTION

Figure 4.

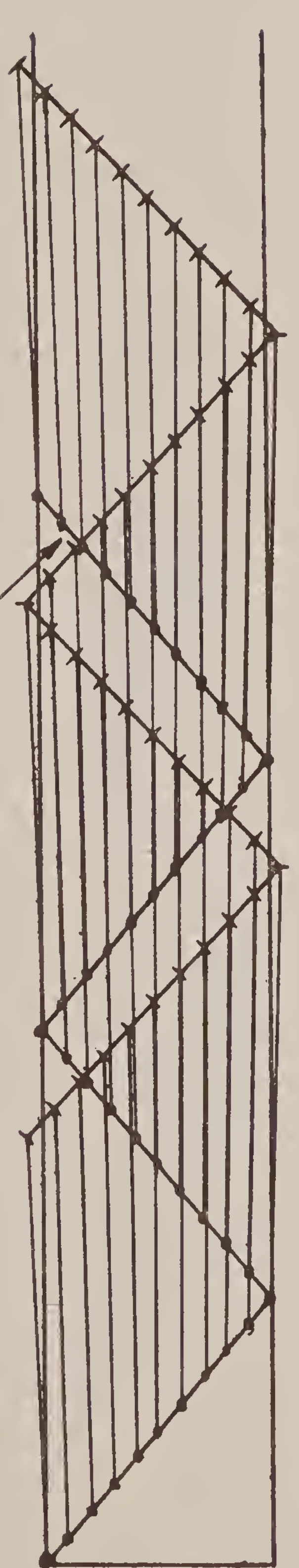


Figure 5.

Figure 6.

SCALE 1 FT.

Figure 7.

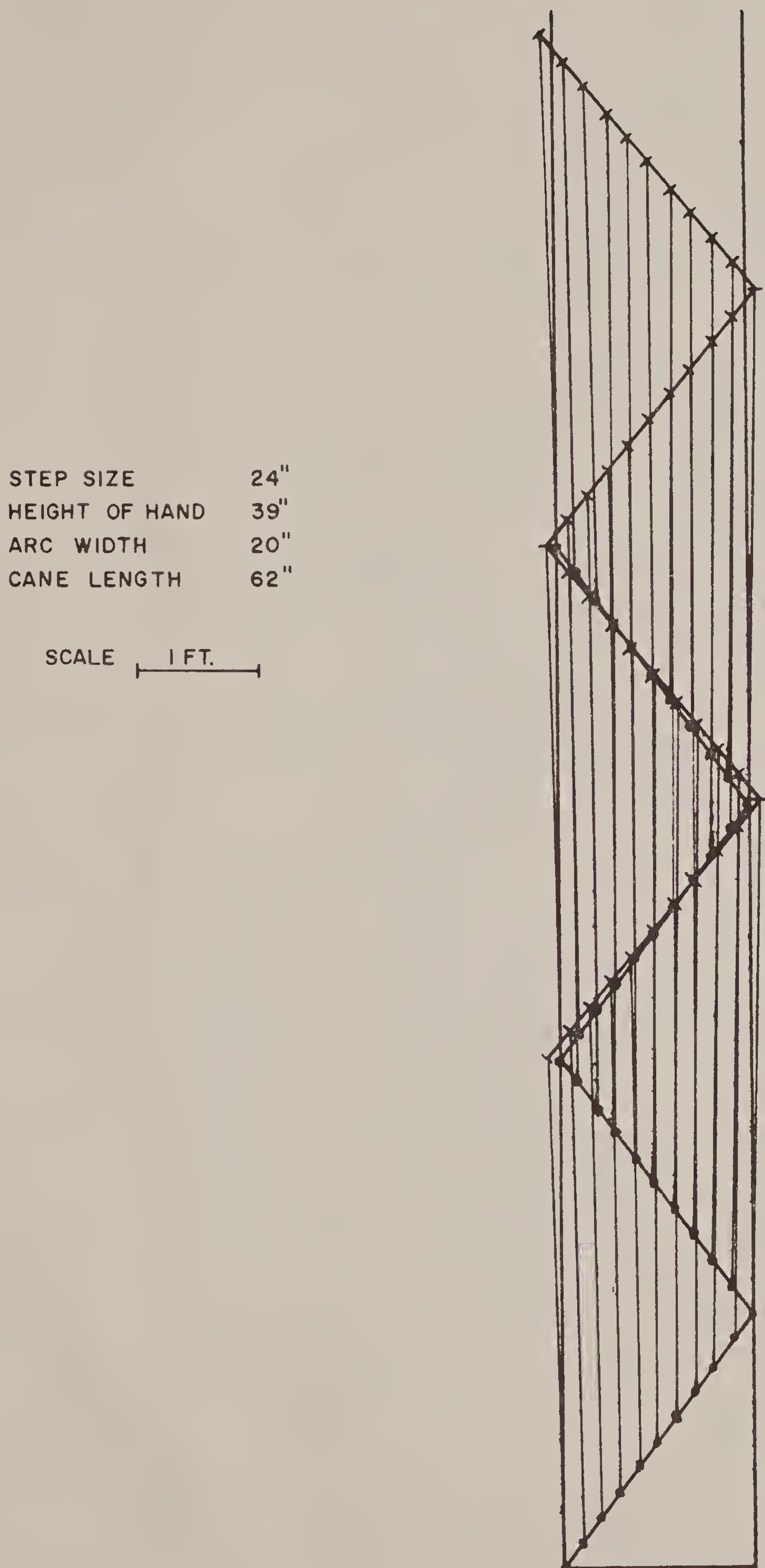

STEP SIZE 24"
HEIGHT OF HAND 39"
ARC WIDTH 20"
CANE LENGTH 62"
SCALE 1 FT.

Figure 8.

DATE DUE

Reference Copy